LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Request to renew Exemption 1(f)

under the RoHS Directive 2011/65/EU

Mercury in single capped (compact) fluorescent lamps not exceeding (per burner) For Special purposes: 5 mg

Date: January 15, 2015

Contents

1 Name and contact details

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2 Reason for application

LightingEurope submits this application to:	*request for extension of existing exemption* ***no. 1(f) in Annex III***
LightingEurope proposes to continue using the existing wording which is:	*Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):* *1(f) For special purposes: 5 mg*
LightingEurope requests a duration of	*Maximum validity period, expiry date not required*

3 Summary of the exemption request

The validity period of DIRECTIVE 2011/65/EU Article 5(2) Annex III Exemption 1(f) will end automatically per 21/07/2016, unless an application for renewal has been made to the Commission in accordance with Annex V.

With reference to the above, this request concerns the extension of the current Annex III exemption 1(f) regarding mercury in single-capped (compact) fluorescent lamps for special purposes.

These lamps in exemption 1(f) generate UV light and are used for several area's in medical, disinfection and other applications, where an efficient source for UV light is needed.

Although the level of mercury used in (compact) fluorescent lamps has been decreased considerably during the last years, the technology needs a small amount of mercury in order to function through the full indicated lifetime.

On the other hand more and more LED solutions come to the market, but still there is no proper full compatible replacement for CFL lamps for these special purposes. The main reason is that LED based light sources with the correct spectra are not available, there are differences in size, in the light distribution and the match with the separate ballasts can be problematic.

That is why LightingEurope is requesting an extension of current exemption with a maximum validity period and no expiry date.

4 Technical description of the exemption request

4.1 Description of the lamps and their applications

4.1.1 Lamps covered by this exemption

This exemption covers single capped (compact) fluorescent lamps for special purposes.

Single ended (compact) Fluorescent lamps for special purposes can be applied both in professional and consumer applications. They differ in construction from general lighting lamps by the use of different glass and phosphors (for some no phosphor), typically emitting in UV or blue wavelength bands, as to fulfil special purposes like:

- disinfection of air, water or surfaces,
- (medical) skin treatment, including
    - Tanning
    - Narrowband and Broadband UVB phototherapy
    - PUVA phototherapy
    - UVA-1 phototherapy
- treatment of neonatal jaundice,
- insect attraction in insect traps,
- photo-polymerization of plastics (nail curing, contact lens manufacturing, etc.)
- counterfeit detection (money checkers)
- forensic investigation (UV light to detect organic material)
- enhancing colours of fish in aquaria
- fluorescence by black lights in disco’s

- many other applications.

They are to be installed in dedicated equipment for such applications.

The power of Compact Fluorescent Lamps for Special purposes ranges from 5W – 110W.

There is a huge variety in product designs because of their specific purpose, technology, wattage, size and compactness, life time, internal phosphor coating, production process etc. Below a few examples of the various lamp types (figure 1), applications (figure 2) and lamp spectra (figure 3) are shown.

Figure 1 Lamp types

Application examples covered by this exemption

Figure 2 Applications

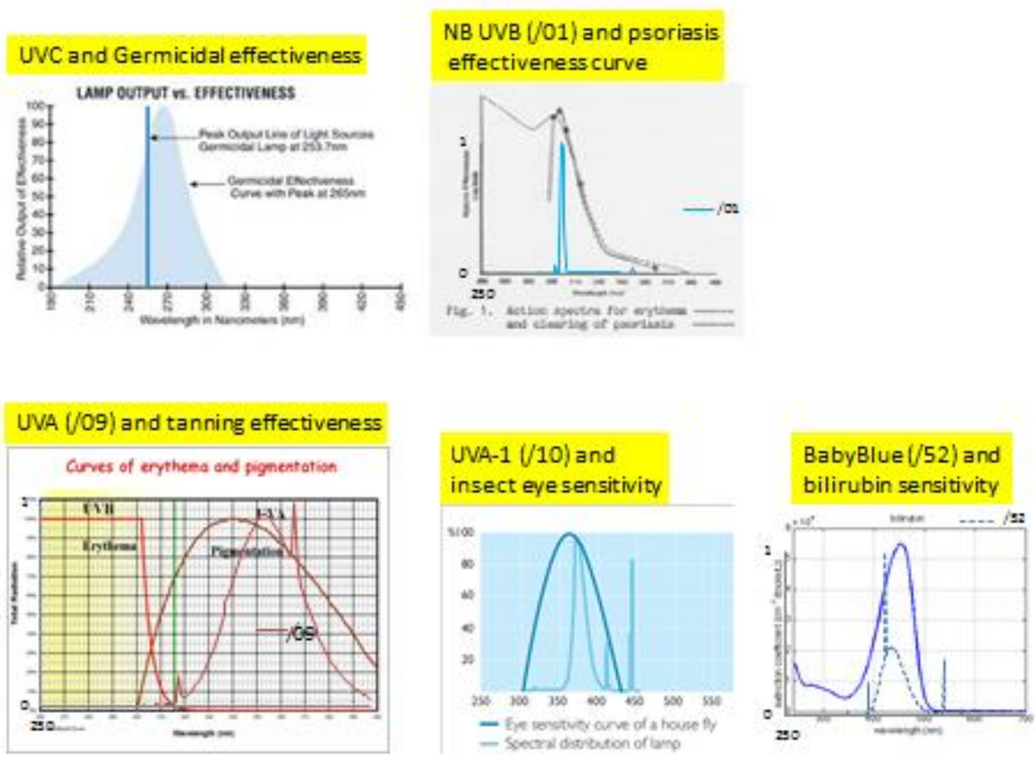

Figure 3 Lamp spectra and responses

4.1.2 Annex I category covered by this exemption.

List of relevant Annex I categories for this exemption

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☒ 5

☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11

Application in other categories, which the exemption request does not refer to: N/A

Equipment of category 8 and 9: N/A

The requested exemption will be applied in

☐ monitoring and control instruments in industry

☐ in-vitro diagnostics

☐ other medical devices or other monitoring and control instruments than those in industry

LightingEurope is of the opinion that lamps in general are category 5, because the majority is used for general illumination. However, they have some of the characteristics of components (used in luminaires), consumables (finite lifetime and regularly replaced) or spare parts (lamps in luminaires have to be replaced when they cease functioning). Some manufacturers of electrical equipment in other RoHS categories may install fluorescent lamps into their equipment for general illumination purposes and so they will need to use lamps that comply with the RoHS directive, however the products that they place on the market are not category 6 but may be household appliances, medical devices or potentially in any RoHS category 1 - 11.

LightingEurope is aware of the difficulty to classify certain lamps unambiguously in the category set out by RoHS legislation. For lamp producers it is essential to have legal certainty regarding the possibility to put the products on the market irrespective of the planned application as we are not able to control the use of the lamps in products falling in other categories or out of the RoHS scope. In practice, most lamps are installed in buildings for lighting applications (category 5), but some are used in other types of equipment in all other RoHS categories. The way that lamps are used has no effect on lamp design so will not affect this exemption request.

4.2 Description of the substance

4.2.1 Substance covered by this exemption

LightingEurope is asking for exempting

☐ Pb ☐ Cd ☒ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

4.2.2 Function of mercury in lamps

Electrons are emitted from a heated electrode colliding with mercury atoms and so transferring energy to the atoms which elevates them to an excited state. When these atoms fall back to their original status they emit photons (packages of energy), in the UV-C range. For disinfection lamps this UV-C radiation is near the optimum in the germicidal action spectrum, thereby killing bacteria and viruses. For other special purpose lamps, the ultraviolet photons excite the fluorescent powders, which are coated on the inside of the tube, with a high degree of efficiency. As a result these emit radiation in either UVB, UVA or certain visible (blue) wavelength bands. Lamps based on these principles and operating at low internal gas pressure are called ‘fluorescent lamps’.

4.2.3 Location of mercury in lamps

Mercury is present in the so-called discharge tube.

The mercury is instrumental in the conversion of electrical energy into the UV radiation, which is converted subsequently by a phosphor into emitted radiation in other wavelength bands.

4.2.4 Amount of mercury

Mercury is dosed in the burner during lamp manufacturing as homogeneous material (pill, capsule or as amalgam). This technology enables dosing of the small and accurate amount of mercury that is needed, without unintended losses. The amount of mercury dosed per lamp depends on aspects like lamp power, optical performance and anticipated lamp life. This is reflected in the current individual RoHS exemptions 1(a) till 1(f). During lamp life, mercury is consumed inside the burner itself. It is bound principally to the phosphor layer and the glass.[1] Once the mercury is bound to these elements, it is no longer available to emit ultraviolet light.

One of the principal design rules to create higher lumen packages in fluorescent lamps is to increase the length of the discharge. Consequently higher lamp wattage involves more glass and phosphor surface, thus more mercury consumption during lamp life and therefore a higher initial mercury dose. Coating of phosphors and glass can give a reduction of the Hg consumption over lamp life, but in general it remains a function of the lamp dimensions and the lifetime. Next to this, processing has its influence, for instance because the actual dose per lamp scatters around the nominal dose, while the threshold value as set by RoHS directive sets a maximum limit.

For single capped compact fluorescent lamps in the scope of the Exemptions 1(f), the maximum dosed mercury amount is set at 5 mg.

The influence of mercury consumption on the required dose

The amount of mercury which is needed for the low pressure discharge itself is very low, typically below 0,1 mg per lamp. But there are many processes within the burner, which make a large part of the mercury unavailable for the discharge over lifetime. This is called mercury consumption. The mercury consumption is much higher than the mercury amount needed for the discharge, viz. in the order of a milligram. This is the reason why more mercury has to be dosed to make sure the intended lifetime is not shortened due to too little available mercury. Therefore a balance has to be found between mercury needed over lifetime, mercury variance per dosing unit but also the measurement accuracy when estimating the amount of mercury in a lamp for market surveillance.

[1] Reference: I. Snijkers-Hendrickx et al, Low-Mercury Containing Discharge Lamps. Sustainable and Environmental Friendly Lighting Solutions, LS 11

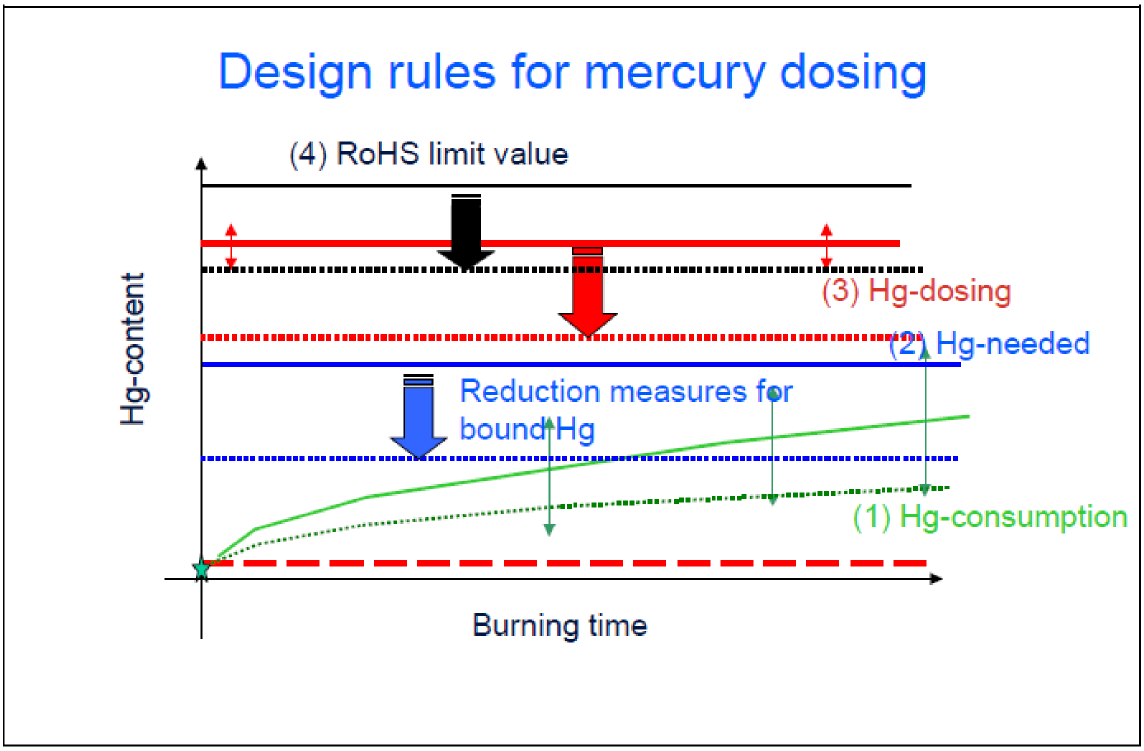

Figure 4 Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.

The lowest (red dashed) line in Figure 4 gives the ideal situation for a low pressure mercury discharge: there is just enough mercury for the discharge to properly function. For a compact fluorescent lamp this is typically in the order of 0,005 to 0,05 mg per lamp (in the gas-phase), depending on the lamp dimensions. However, because of the mercury consumption mechanisms a significantly higher amount must be dosed (which will be explained below). It has not been possible to date to design a lamp with normal functional properties over lifetime using a mercury dose of only 0,005 to 0,05 mg.

In practice, mercury from the discharge is consumed over lamp life. The mercury is mostly deposited and effectively bonded to the glass and the phosphor layer. This is reflected by the full green curve (1) in Figure 4, which represents more or less a square root relationship with lamp life. The longer the burning time, the higher the amount of mercury needed. The variance in this mercury consumption, as depicted by the green arrows, is considerable and depends on many factors (see below for counteracting measures). To obtain the designed lamp life, the right amount of mercury has to be dosed, taking into account the consumption during lamp lifetime and the variance. The solid blue line 2 in figure 4 represents the typical amount that is needed and the solid red line 3 is the amount that also incorporates the variance. Alternatively, this target value is called nominal or average value, and can be listed in catalogues. This average value is lower than the threshold value so the actual amount per lamp is lower than the limit set by the directive.

The solid black line 4 in Figure 4 is the line representing the RoHS limit (expressed as mg per lamp), the value of which, as explained before, has to take into account both variances of mercury consumption and of mercury dosing. On the one hand, we would like to have this value as low as possible, but on the other hand, it should be safely chosen to (1) eliminate the customer risk of a non-performing product over the designed lamp life and (2) to be able to demonstrate in internal manufacturer's tests and in market surveillance tests that products comply with the RoHS Directive. This leads to a built-in safety margin on top of the target mercury dose, finally leading to RoHS content limit. The lifetime and performance of CFL lamps in Europe are regulated[2],[3].
Figure 5 shows the dosing variance relatively to the RoHS threshold value.

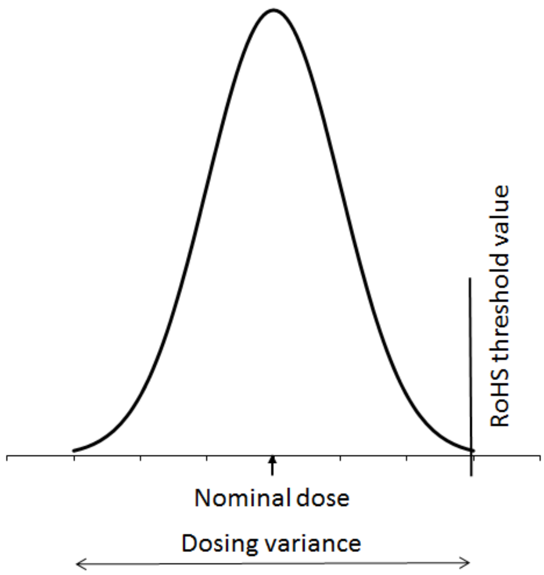

Figure 5: Dosing variance in mercury

Key to the reduction of mercury that has been applied by lamp manufacturers in the previous decades is influencing the factors that determine mercury consumption. These include:

[2] Commission regulation (EC) No. 244/2009, March 18, 2009
[3] Commission regulation (EC) No. 245/2009, March 18, 2009

- Glass type and protective coating
- Type of phosphor material
- Interaction with gasses and impurities
- Lamp processing during manufacturing
- Lamp-ballast interaction during operation

It is also important to take into account the technical capability to reduce both the absolute mercury dose to very low values, and to reduce its variance. Hence, by combining a series of interlinked and complex measures, in a consistent manner, the mercury has been reduced, based on scientific and technical progress in recent years.

4.2.5 Environmental assessments, LCAs

There are several external LCA's performed regarding lighting. There is general agreement, that the main environmental impact is created during the use phase, meaning through electricity consumption when burning the lamp.[4] This means that currently the efficacy of the lamp is the determining parameter. Specifically regarding mercury, the biggest amount is released to the environment by power plants when generating energy (especially when coal is the primary power source).[5] Technological advancements in the lighting industry have resulted in a significant reduction in the amount of mercury used in many types of fluorescent lamps over the last two decades.[6] Manufacturers have developed technology that enables a small amount of mercury to be 'dosed' or placed inside a CFL.[7]

Since there are no retrofit LED lamps in the special lighting application with enough power and good conversion efficiency in the relevant UV wavelengths the LCA comparison with LED's does not make sense in this renewal request for the exemption.

[4] see Enlighten report, Section 5, Ch. 3 fig. 4 & 5, p. 111-112 http://www.learning.enlighten-initiative.org/ebook/en_lighten_english_complete.pdf

[5] see Enlighten report, Section 5, Ch. 3 fig.6, p. 111-112 http://www.learning.enlighten-initiative.org/ebook/en_lighten_english_complete.pdf

[6] ENERGY STAR. (2012). Frequently Asked Questions Information on Compact Fluorescent Light Bulbs (CFLs) and Mercury. Retrieved March 29, 2012, from: http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf, UNEP toolkit, p.106

[7] Complete paragraph UNEP toolkit, p.106

5 Waste management

5.1 Waste streams

☒ Article is collected and sent without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

- ☐ The following parts are refurbished for use as spare parts: ______
- ☐ The following parts are subsequently recycled: ______

☐ Article cannot be recycled and is therefore:

- ☐ Sent for energy return
- ☐ Landfilled

Single capped (compact) fluorescent lamps are in the scope of EU Directives 2002/96/EC - WEEE and 2012/19/EU– WEEE Recast. Take back systems are installed in all EU Member States: end users and most commercial customers can bring back the lamps free of charge. Single capped (compact) fluorescent lamps (also for special purposes) are collected separately from general household waste and separately from other WEEE waste. Also a dedicated recycling process exists for lamps because, according to legislation, the mercury shall be removed from the gas discharge lamps. Mercury is recovered in specialised facilities by distillation. Figure … shows the various steps in the recycling process.

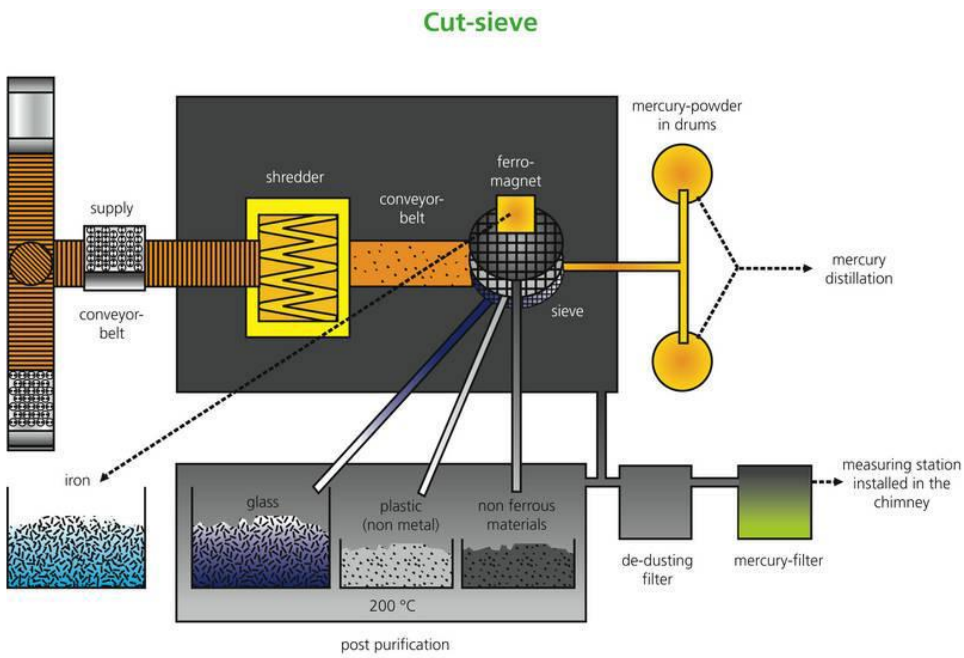

Figure 6 Recycling steps of fluorescent lamps in Indaver (Belgium). Source:www.indaver.be/waste-treatment/recycling/mercurial-waste.html

The next picture illustrates the specifics of recycling the mercury:

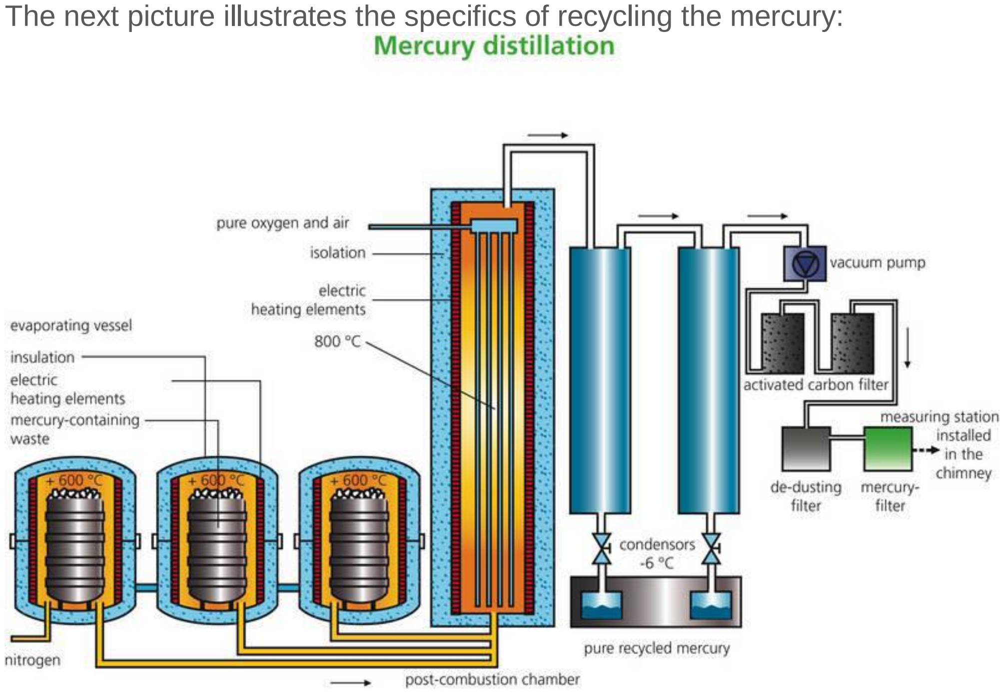

Figure 7 Specific recycling steps of mercury in Indaver (Belgium). Source:www.indaver.be/waste-treatment/recycling/mercurial-waste.html

European legislation on Waste Electrical and Electronic Equipment makes producers responsible for end of life products within this category as from August 13th, 2005. Target setting as consequence of the present legislation is 45% of EEE placed in the market by 2016, rising to 65% in 2020 per year for all categories.

European Lamp Companies have founded Collection & Recycling Organizations in the EU Member-States, with the objective to organize the collection and recycling of gas discharge lamps. Goal is to comply with present and probable future EU legislation and meet or exceed national targets.

In general the following channels have been established in the respective member-states providing countrywide coverage:

- Direct collection from large end users:

  Containers have been made available, ad hoc or permanently, and will be collected upon notification by the end user that the container is full.

- Collection through distribution:

  Wholesalers and Retailers place collection means at their premises respectively in their shops. Collection is done upon notification.

- Collection through municipalities:

  Where infrastructure allows collection means are placed at municipality depots.

Campaigns are being executed or have been planned to re-enforce the role of the government to educate the population that gas-discharge lamps have to be disposed of in an environmentally friendly way.

5.2 Amount of mercury in WEEE

☐ In articles which are refurbished

☒ In articles which are recycled

☐ In articles which are sent for energy return

☐ In articles which are landfilled

The amount of substance entering the EU market annually (base year 2013) through application for which the exemption is requested:

For special purposes no data is available on market size and therefore not on amount of mercury. Best estimation from LightingEurope is that it is < 0.1% of general lighting market, what equals to approx. 0,4 Mpcs[8].

The collection rate of lamps in Europe compared to the average amount of lamps put on the market during 2010 – 2013 is shown in below graph based on Collection & Recycling Service Organization (CRSO) data consolidated by Philips Lighting. It also includes the targets set for 2016 and 2019. Please be aware that this graph includes all lamp types, not specifically the CFL for special lighting types.

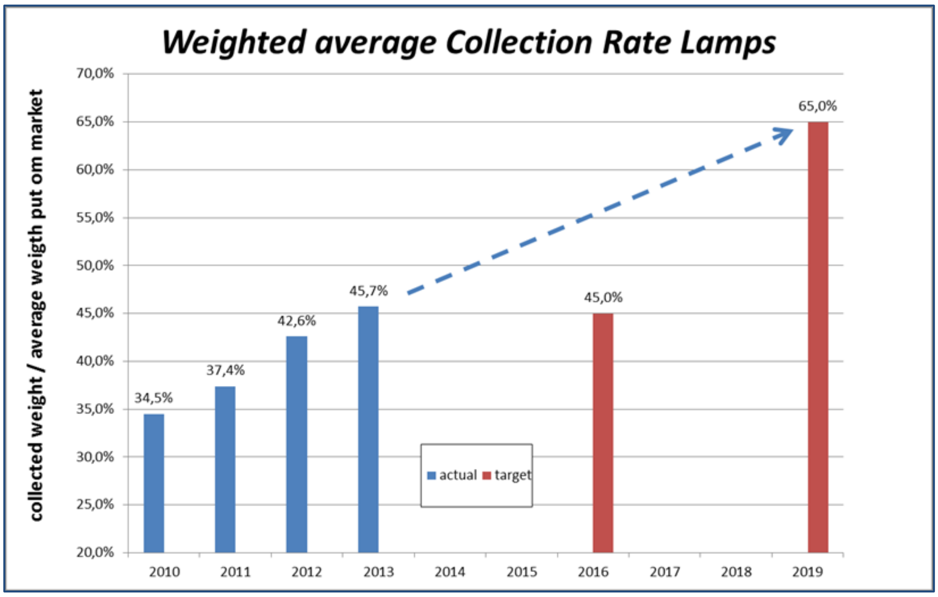

Figure 8: Collection rate of lamps

Reporting on the collection of lamps is available on 2 groups:

- CFL lamps and LED retrofit lamps
- Fluorescent tubes, long CFL without integrated ballast

This makes it impossible to give specific accurate figures for single capped (CFL) special purpose lamps as the available information covers the whole CFL group.

The amount of mercury entering to EU market with CFLs for special lighting can be estimated with the following algorithm.

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[8] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'). Draft Interim Report, Task 2 by Prepared by VHK, in cooperation with VITO and JeffCott Associates Date: 19 November 2014, Table 1.
Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'). Draft Interim Report, Task 2 by Prepared by VHK, in cooperation with VITO and JeffCott Associates Date: 19 November 2014, Table 29.

Based on experience of the LE members, CFL special purpose lamps count for 0,1% of the total CFL volumes in Europe.

The maximum allowed mercury content for CFL lamps for special lighting is 5 mg.

Combining these numbers indicate that in 2013 (0.1% * 400Mpcs * 5mg) a maximum of 2 kg of mercury has entered the European market.

It is unclear if and how fast the amount of lamps and therefore of Hg will go down for the coming years. It will most likely remain stable.

6 Substitution

Can the substance of this exemption be substituted?

☐ Yes, by
- ☐ Design changes:
- ☐ Other materials:
- ☐ Other substance:

☒ No
Justification: see in below chapters

6.1 Substituting mercury in the fluorescent technology

Fluorescent lighting technology.

Fluorescent lamps need a certain amount of mercury since it is consumed over life. Technology has evolved over the last decade. And the average amount of mercury within fluorescent technology per lamp is considerably reduced (Fig 8).

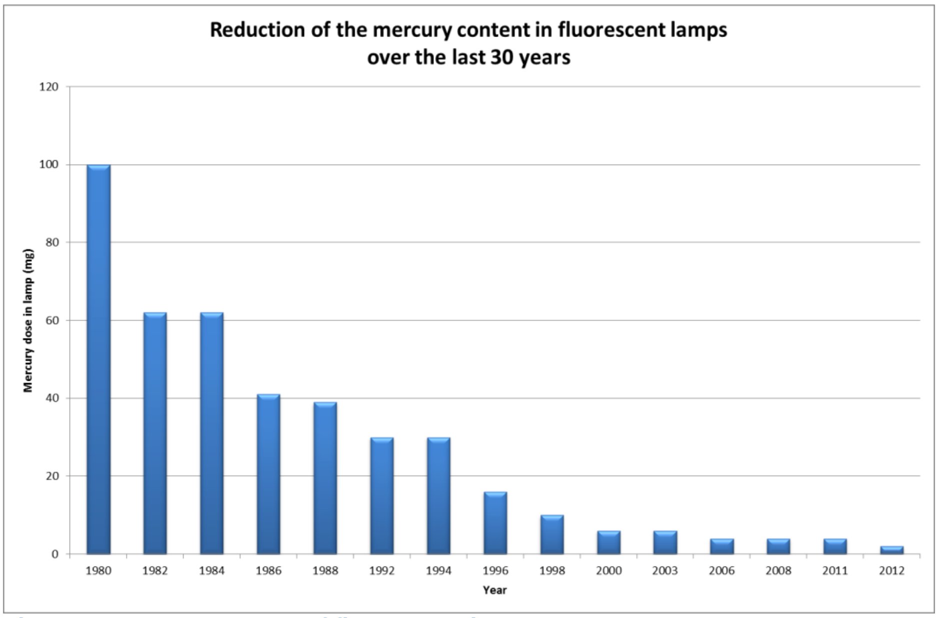

Figure 9: Mercury content of fluorescent lamps

But low pressure fluorescent lamps without mercury are not possible, despite all the research that has been done on the subject:

The mercury discharge is highly efficient in transforming electrical energy into light. The technology has only two drawbacks: first the generated UV radiation needs to be transformed into visible light, a process for which large losses occur: this is due to the Stokes shift (an energetic UV photon generates a visible photon which has a much lower energy) and secondly the discharge inherently contains mercury as the source to create the UV photons[9].

Attempts to generate UV with noble gases have succeeded partially[10]. However the plasma radiates in the deep UV. At such wavelengths, the Stokes shift is even larger causing lower energy efficiency. The lack of suitable phosphors[11] prohibited progress in this direction. Other alternatives investigated are low pressure metal halides (for example InI, InBr, GaI3)[12]. Such plasma's generate the visible light directly without the Stokes shift of the phosphor[13]. There are alternatives from research but the energy efficiency in prototype lamps is significantly reduced to 40lm/W or below. Mass production is not feasible.

With the arrival of the first energy efficient LED white light sources and the perspective of further improvements, research to alternative gas discharges has stopped at most companies and universities.

6.2 Substituting fluorescent technology by other technologies

One can consider all kinds of other lighting technologies as substitution for fluorescent technology. For purification applications, amongst these are incandescent, halogen, LED, OLED and DBD (dielectric barrier discharge). Of these incandescent, halogen and OLED lamps cannot produce radiation in the range that is required for applications of lamps covered by this exemptions. We will discuss further only DBD and LED.

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[9] M Haverlag, Mercury-free discharges for lighting, J. Phys. D: Appl. Phys. 40 (2007)

[10] R Bussiahn, S Gorchakov, H Lange, D Loffhagen and D Uhrlandt, Ac operation of low-pressure He–Xe lamp discharges, J. Phys. D: Appl. Phys. 40, 3882 (2007)

[11] J. Dexpert-Ghysa, Re-processing CRT phosphors for mercury-free applications, J. of Luminescence, 129, 1968, (2009)

[12] D.Smith, J. Michael, V. Midha, G. Cotzas and T. Sommerer D. Smith et al Efficient radiation production in a weakly ionized, low-pressure, nonequilibrium gallium-iodide positive column discharge plasma J. Phys. D: Appl. Phys. 40 3842 (2007). More references can be found in the series: International Symposium on the science and technology of Lighting LS1-14.

[13] An example if a UV photon of 256 nm from mercury is transformed in a visible photon of 555nm (maximum eye sensitivity) 56% of the energy is lost to heat. In xenon the UV photon is formed around 185 nm this loses 67% of the energy when transformed into the same visible photon.

For any new technology one needs to address the replacement market (replacing lamps in existing fixtures) and the market for new equipment using the new technology.

The criteria to determine whether a new technology can replace existing fluorescent lamps using mercury in existing equipment are:

- Lamp specification must be same with regards to
  - Radiation Output
  - Spectral power distribution
- Safety and reliability must be assured
- Compatibility must be assured (Electrical and mechanical specification)
- Effectiveness to reach the desired effect (tanning result, phototherapeutic effect, insect attraction rate, etc) must be met
- Compliance with CE regulations / approbation
- No (negative) side effects
- Economically feasible (cost of replacement technology)

For new equipment using technologically new light sources similar criteria hold:

- UVA and UVB output must be similar
- Spectral power distribution must be similar
- Safety, reliability must be assured
- Compatibility must be assured (Electrical and mechanical specification)
- Effectiveness to reach the desired effect (tanning result, phototherapeutic effect, insect attraction rate, etc) must be met
- Compliance with CE regulations / approbation
- No (negative) side effects
- Economically feasible (cost of replacement technology)

InstantTrust, a disinfection lamp system for water dispensers, based on a dielectric barrier discharge, can be considered as an alternative technology without mercury. However these lamps cannot replace the current installed base of Compact Fluorescent lamps within water dispensers, since the electrical and mechanical interface is completely different. The lamps cannot be used outside dedicated installations for water treatment.

6.2.1 Feasibility of the alternatives

LEDs in principle could be chosen as radiation technology for special purposes, provided following (retrofit) criteria are fulfilled:

1. Wall Plug Efficiency [14] is comparable to fluorescent lamps
2. Effectiveness is comparable to fluorescent lamps (i.e. same tanning effect, photo-therapeutical effect, insect attraction rate etc.)
3. Regulation/approbation is passed

In the following chapter each of these 3 criteria are discussed.

1. Wall Plug Efficiency
   a. In contrast to general lighting lamps, (compact) fluorescent lamps for special purposes emit radiation in UV or blue wavelength bands. LEDs for general lighting purposes are made of InGaN, a material that emits blue light which with the help of phosphors is converted into the desired visible wavelengths. Theory says you can only convert from shorter wavelengths to longer. It is therefore impossible to create UV light with LED material as used for visible light LEDs.
   b. There are other materials available from which LEDs can be made that generate UV light (like AlGaN), however the efficiency (radiated power out / electrical power in) of LEDs with those materials is still very low. In the UVC (100-280nm)

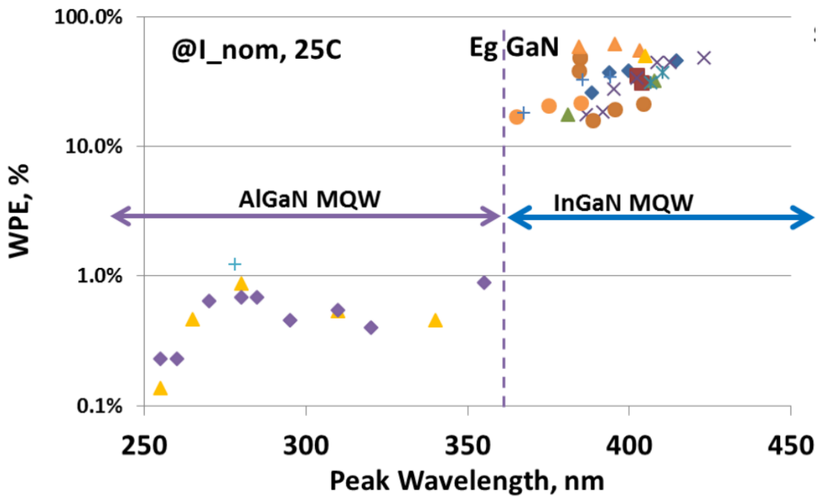

Figure 10 LEDs (UVC-Blue): WPE vs wavelength (data of several manufacturers)

and UVB (280-315nm), the WPE (wall plug efficiency of LEDs are below 1%), where the wall plug efficiency of fluorescent lamps are close to 20% or even

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[14] Wall Plug efficiency: Useful UV power divided by the power used by the whole lighting device (including control gear) from the mains power supply.

higher. See below pictures 6 and 7 in which public data from several manufacturers are put together in one graph.

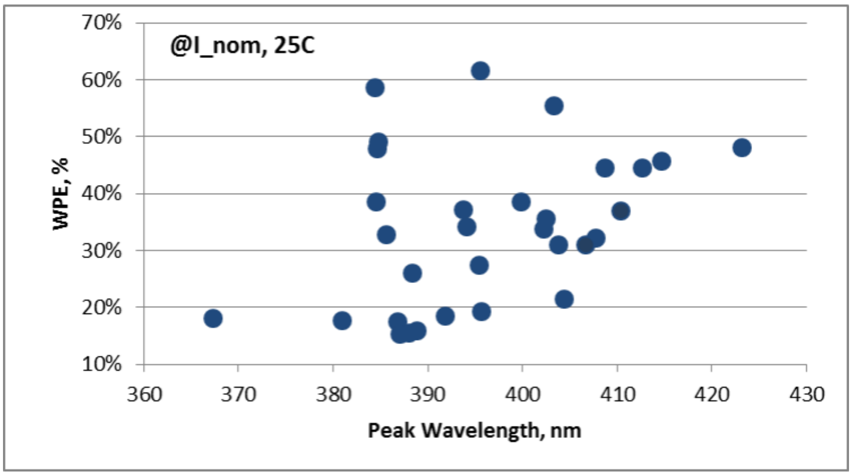

Figure 11 UVA-LEDs: WPE vs wavelength (data of several manufacturers)

Conclusion: No comparable WPE for LEDs below 380 nm; making LED not suitable soon as a practical alternative for:

- Disinfection/purification of air/water/surfaces
- Broadband and Narrowband UVB Phototherapy
- PUVA phototherapy
- Tanning

2. Effectiveness is comparable

For most special purposes no tests results are available yet w.r.t. effectiveness to reach the desired effect in a comparison study between equipment using (single capped) fluorescent lamps and equipment using LEDs. For most of these applications that is not done yet as no LEDs were available.

For some applications, in e.g. nail curing equipment using LEDs is on the market but turns out to be less effective and longer curing/treatment times are necessary. For some other curing applications new photo-initiators have been developed to be able to cure at wavelengths where LEDs are available at a reasonable price.

For e.g. insect trap applications (not yet publicized) studies using LEDs so far show negative results with respect to their ability to attract insects as compared to BL (or BLB) lamps.

For treatment of baby jaundice equipment using blue LED is quite common, as it has proven to be a feasible alternative. Still however (single capped) fluorescent lamps are used as the cost of lamp replacement is much lower than replacement of the complete equipment. Retrofit LED lamps are not allowed due to approbation requirements. Renewal of approbation with retrofit LED lamps is not endorsed by equipment companies.

For black lights and aquarium lamps LEDs may provide an alternative, although the (visual) effects of single capped fluorescent lamps and LEDs are not comparable.

3. Regulation/approbation is passed

CE conformity and other European directives for special purpose applications (like for instance approbation of medical devices for phototherapy) is based on fluorescent lamps (with respect to safety and system responsibility). Furthermore, most alternative lamps in practice need replacement of the equipment ballast. Effectively, this would imply that the complete equipment needs to be replaced, which produces additional waste when still properly operating components need to be disposed.

Current equipment using compact fluorescent lamps is not designed to take care of the heat generated by LEDs. (Where in lamps the generated heat is mostly radiated away, with LEDs the heat has to be transported away by conduction.). Spare part replacement of compact fluorescent lamps with LED based lamps is therefore generally not possible.

Current equipment using compact fluorescent lamps are designed to have a very homogenous spatial radiation distribution compared to LED retrofit lamps. The more directional light of an LED will give a different radiation distribution in the same equipment.

The lamp driver can be conventional electromagnetic ballast or a high frequency electronic driver. The market for new installations is moving toward electronic drivers due to new functionality (e.g. dimmability) and upcoming energy efficient legislation for the driver. The professional CFL lamps are designed to be dimmable.

Several modes of dimming (e.g. phase cutting) are present in the market. All modes of operation (EM, HF current controlled, power controlled, voltage controlled, preheat, non-preheat) have in common that the light source is expected to behave electrically as a standardised CFL lamp. The large diversity of drivers is not meant for an electronically ballasted LED lamp and there is no interface described for LED lamps yet. This makes it difficult to know for a customer which ballast is used and what LED lamp to apply as retrofit. A wrong combination can lead to instable lamp power for the LED (light flicker) and even to safety problems. A regular ballast for a professional CFL lamp is designed to be used with several subsequent lamps (at least 3-4 lamps). So if the combination of the ballast with the LED lamp is not working or even not available, the ballast needs to be changed prematurely.

Conclusion is that LEDs do currently not provide a viable alternative for replacing single capped fluorescent lamps for special purposes.

6.2.2 Availability of substitutes

UV LEDs are available from several suppliers. However, as is clear from above efficiency is very low. No public roadmaps exist that predict when UV LEDs with acceptable output and efficiency are available. Only after that design and development of LED based equipment can start and after that customer/patient tests could start.

6.2.3 Impacts of substitution

Apart from feasibility and availability also potential impacts of substitution must be considered.

6.2.3.1 Environmental impact of substitutes

For UV-C and UV-B: dramatically higher energy consumption due to low efficiency of currently available UV-C and UV-B LEDs

For UV-A: Also for applications needing below 380 nm energy consumption will go up due to low efficiency of UV A LEDs in that wavelength region.

For all:

Most alternative lamps in practice need replacement of the equipment ballast. Effectively, this would imply that the complete equipment needs to be replaced, which produces additional waste when still properly operating components need to be disposed.

As stated before, various LCA's show different results and so are inconclusive regarding the comparison of LED technology versus fluorescent technology on energy use and total environmental impact.

With reference to the LCA on halogen, CFL-I and LED (Details Osram 2009):

For comparable lifetime and energy efficiency single capped (compact) LED lamps for special purposes replacing single capped (compact) fluorescent lamps for special purposes need more materials, like integrated ballast, (aluminium) heat sink and plastic materials.

For light sources in professional applications, economic and environmental consequence of prohibiting mercury would result in a mandatory refurbishment of installed luminaires while still operating correctly (not yet at end-of-life) when employing right light source component replacements. This would result in the creation of a lot of additional unnecessary waste on the EU market. Typical life cycle of equipment in disinfection, medical and insect trap applications is 20-50 years

6.2.3.2 Health and safety impact of substitutes

Although the LED technology doesn't contain mercury, it may contain other sorts of substances as lead and plastics. So far researches have not been conclusive in the overall effect of a LED lamps in comparison with a CFL lamp.

6.2.3.3 Socio-economic impact of substitution

Economic effects related to substitution:

- ☐ Increase in direct production costs
- ☒ Increase in fixed costs
- ☐ Increase in overhead
- ☒ Possible social impacts within the EU
- ☒ Possible social impacts external to the EU
- ☒ Other:

Closing of factories in the EU with accompanying loss of jobs

Banning these lamps leads to an increased spent of EU consumers due to enforced usage of more expensive LED lamps (no cheaper alternative yet) or to an increase of use of less energy efficient alternatives.

Alternative technologies to be implemented implying additional investments
Enforced replacement of installed luminaire and lighting system base for single capped (compact) fluorescent lamps while still economically feasible when replacement components would be available.

6.2.3.4 Impact of substitution on innovation

Focus of the current lighting industry is already on the further development of LED technology. An extension of the exemption will have no negative effect on the efforts to further innovate in LED.

6.2.4 Future trends of substitution

LED development is fast in general lighting while special purpose lamps are for a niche market where the LED development is somewhat slower. LED technology performance is developing, however the balance between cost price, lifetime and efficiency and the speed in which it will take place is not yet clear.

6.3 Links to REACH, according to RoHS Directive Article 5(1)(a)

Do any of the following provisions apply to the application described?

no

- ☐ Authorisation
  - ☐ SVHC
  - ☐ Candidate list
  - ☐ Proposal inclusion Annex XIV
- ☐ Restriction
  - ☐ Annex XIV
  - ☐ Annex XVII
  - ☐ Registry of intentions
- ☐ Registration

Provide REACH-relevant information received through the supply chain.

Not Applicable

7 Removal of mercury from lamps

Can mercury be eliminated?

- ☐ Yes.
- ☒ No, as explained in 6.1

8 Reduction of mercury content of lamps

In paragraph 6.1 is explained that various attempt have been made in the industry to reduce the mercury content in fluorescent technology. These attempts have been successful, because the amount of mercury has been drastically reduced in the last decades. At the same time, the fluorescent technology can only operate when a certain limited amount of mercury is used. As stated before, there is interdependency between the amount of mercury, the light output per wattage (efficacy) and optical performance, and the lifetime of the lamp. To be able to keep this fine balance, it is uncertain if the amount of mercury as stated currently in RoHS can be reduced while keeping the requirements of lifetime, optical performance and energy efficiency.

9 Other relevant information

Not submitted in this document.

10 Information that should be regarded as proprietary

LightingEurope provides to the European Commission under confidentiality a comprehensive list of lamps with average mercury content, which are in the scope of the obligation to publish such data according to the ErP Directive Implementing Measures 244/2009, 245/2009, 1194/2012 and produced by LightingEurope member companies.

List of abbreviations

ADCO	Administrative Cooperation Group
BASI	Bioanalytical Systems, Inc
BSP	Barium Synthetic (Pb^{2+}) phosphor
CCG	Conventional Control Gear
CDM	Ceramic Discharge Metal Halide
CDV	Committee Draft for Voting
CFL	Compact fluorescent lamp
CRI	Color rendering index
CRSO	Collection & Recycling Service Organization
DEFRA	Department for Environment Food and Rural Affairs
DOE	Department of Energy
ECG	Electronic Control Gear
EEE	Electrical and Electronic Equipment
ELC	European Lamp Companies Federation
EM	Electromagnetic: lamp control gear based on a magnetic coil (= CCG)
EMC	Electro Magnetic Compatibility
ERP	Energy related Products; Directive 2009/125/EC establishing a framework for the setting of eco design requirements for energy-related products
FTE	Full Time Equivalent, indicates the workload of an employed person
HF	High frequency: lamp control gear based on high frequency (= ECG)
HID	High intensity discharge lamps
HPS	High Pressure Sodium (vapor) lamps
Hz	Hertz
K	Kelvin: Unit of color temperature (2700 K warm color, 5600K cool daylight)
Lm	Lumen
LFL	Linear Fluorescent Lamps
LCA	Life cycle assessment
LED	Light Emitting Diode
LPD	Low Pressure Discharge lamp
LVD	Low Voltage Directive

mg	Milligram
MH	Metal halide lamps
OEM	Original equipment manufacturer
OLED	Organic Light-Emitting Diode
PCA	Poly-crystalline alumina
PLL	Pi shaped Long Length, compact fluorescent lamp
R&D	Research and Development department(s)
REACH	Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals, 1907/2006/EC
RoHS	EU Directive 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment
SSL	Solid State Lighting
SVHC	Substances of Very High Concern
TF	Task Force
UMICORE	global materials technology group which focuses on application areas where its expertise in materials science, chemistry and metallurgy makes a real difference.
UNEP	United Nations Environnent Programme
UV	Ultraviolet
VDE	German Association for Electrical, Electronic and Information Technologies
W	Watt unit of (electrical) power
WEEE	Waste Electrical and Electronic Equipment
ZVEI	German Electrical and Electronic Manufacturers´ Association